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Developing Holistic Technology-based
ABSTRACT

In the early 1990's, the Department of Defense (DOD) sponsored an effort to provide a curriculum addressing the training requirements of Course S46 Quality Assurance (QA) of Soldering Technology and Electronic Assembly. This effort resulted in the development of a text-based training course that utilizes a student handbook, instructor manual and photographic slides. The DOD decided to develop a new distance learning program that will take advantage of new innovations in information technology.

The purpose of the project is to create an interactive multimedia-training program to provide the student the basic knowledge necessary for in-plant QA evaluation of soldering and soldered electronic assemblies and the processes. This training program offers an overview of cognitive knowledge of various topics. It does not replace, and must be supplemented by, adequate practical exercises to maintain minimum acceptable skills as a QA specialist.

After systematically analyzing the client's needs and how current training is conducted, it was extracted that large amounts of technical content and complex scenarios must be presented. It is also very important to have instructor-trainee and trainee-instructor interactions. No existing technologies can accommodate the need for large volumes of technical content, instructor-trainee interactions and peer trainee collaborations. The design team at C^2 Multimedia determined that a holistic approach must be taken to deliver the training, using a hybrid form of several cutting edge technologies.

Thus, this paper will describe C^2 Multimedia design team's approach to developing and implementing this innovative training program. The key technologies involved in this program are DVD and online collaborating systems. Digital versatile disc (DVD) can store hours of high fidelity video and large amounts of interactive multimedia courseware on a single disc. This technology and online collaborating systems will be used to form a virtual campus available for the trainees nationwide. This hybrid technology meets the need for delivering high quality interactive courseware, as well as trainee–instructor and peer trainee interactions.

This paper will also address design methodologies, development process, and the technical aspects for implementing DVD and online collaborative technologies.

TECHNOLOGY-BASED TRAINING

The use of state-of-the-art technologies in training is on the rise. More and more training is taking place across a network, Intranet, Internet, video- or audio-conference, or satellite. According to a survey of training managers of the information technology (IT) industry, technology-based training (TBT) is occupying 19 percent of students' training time on average and is expected

to rise to 26 percent in 2000. Many government agencies have devoted many years to the developing and distribution of technology-based training using standard multimedia computer-based instruction (CBI) platforms and over interactive video tele-training (IVT) systems using satellite. The Federal Aviation Administration (FAA), for example, developed and offers more than 245 technical training courses via CBI or IVT. It also offers more than two hundred commercial off the shelf (COS) IT training courses to its employees.

Technology-based training has been gaining more and more ground among government agencies and private companies due to its ability to offer attractive alternatives to traditional classroom/ instructor led training. According to Hall (1999), technology-based training offers flexible, accessible and convenient "just in time and just enough" training. It also promises cost and time saving. Many of the technology-based training stands alone, and students can proceed through a training program "at their own pace and at their own place." They can also access the training at any time, and access only as much as they need. There are little, if any travel costs for bringing remote employees to a centralized workshop. The training is either available from the desktop or from a nearby facility where technology-based training systems can be accessed. According to the report "Return on Investment and Multimedia Training" (Brand Hall, 1999), the actual time required for training by computer averages about 50% that of instructor-led training, lowering costs further.

knowledge/expertise with the students. Unlike the traditional classroom setting,

The "Achilles heel" of technology-based training
As the training community strives to capitalize on the technological advances that have been made available, the importance of a collaborative learning environment, which traditional classroom training offers is often neglected. The lack of instructor-student and student-student interactions in the course delivery can be the "Achilles heel" for many technology-based training courses and may even lead to the failure of the technology based training program.

HOLISTIC TECHNOLOGY-BASED TRAINING (HTBT)

What is HTBT?
An HTBT Program is a virtual learning environment in which students acquire knowledge and skills by studying pre-made materials and collaborating with instructors and fellow students using Internet tools. Such an environment also serves as a performance support system for the trainee on his/her job once initial training is completed. An HTBT consists of these components:

Student/Trainee
Any training program must be student centered in order to be effective. Before the development of a HTBT, there must be a good understanding of the characteristics of students including their education and reading level, knowledge of the subject, learning style, prior experience, and their attitude.

Instructor/field experts
Also in the equation, are the instructors and field experts who share their the instructors and field experts are not responsible for presenting the basic

initial technical content to the students. Instead, their responsibilities are providing learning guidance, answering technical questions, sharing in-depth knowledge, and in some cases certifying the students when they successfully complete the training program. The student/trainee communicates with the instructors and field experts using Internet communication tools such e-mail, chat rooms, instant messaging, and on-line conferencing software.

Peer Students/Trainees
Students learn as much from the course material and the instructors as they do from interaction with their fellow trainees. Thus, another component of the learning environment HTBT affords, is the interaction among students. The student/trainee communicates with other students/trainees using the same Internet communication tools such e-mail, chat rooms, instant messaging, and on-line conferencing software.

Multimedia CBI and EPSS on DVD
Like any computer-based training course, the majority of the training program content resides on a high-capacity storage device, the courseware. The course material is a self-paced interactive computer-based training course developed using an instructional systems design process. The course material is presented in the order predefined by instructors and instructional designers during the design phase of courseware development. In other words, the courseware is put together by a large team of subject matter experts from the field, experience instructors, and expert instructional designers. Using the latest DVD technologies reduces the need for costly updates of the courseware.

technology, hours of high-fidelity video (studio) quality, as well as large amount of information can reside on a single disc with the same size of a conventional CD-ROM. Upon completing the course, a whole suite of tools and resources will be unlocked for the student to use as an electronic performance support system (EPSS). The student can continue to obtain "just-in-time" and "just-enough" training while getting on-line assistance from the EPSS.

Organized Internet Resource
Another distinctive characteristic of HTBT training, is the hybrid-CD-ROM/DVD technology. It does not only incorporate the computer data, digital video in MPEG 1 and/or MPEG 2 format, but also incorporates organized Internet resources such as regularly updated regulations, policies, technical updates, standards and specifications, etc. The information is so seamlessly integrated into Computer Based Instruction (CBI) and reference material, that access to the Internet from the courseware is transparent to the student. Therefore, the student will always get the latest information even with older DVD-ROMs.

Why Will HTBT Work?
An HTBT program integrates Computer-based Instruction (CBI), Electronic Performance Support System (EPSS), and the Internet to maximize the student's access to learning resources. It also creates a virtual learning environment in which a student's learning is not only self-paced, but also facilitated with guidance from experts. The integration of the training materials with the Internet using the hybrid

HOW DOES HTBT WORK

Technologically, HTBT is a virtual learning environment supported by two key technologies: DVD technology and on-line collaboration technologies. The rest of our discussion will focus primarily on these technologies.

DVD TECHNOLOGY

What is DVD?

DVD is the abbreviation for Digital Versatile Disc or Digital Video Disc. It is the next generation of optical disc storage technology. DVD is essentially a bigger, faster CD that can hold video as well as audio and computer data. It aims to encompass home entertainment, computers, and business information with a single digital format, eventually replacing audio CD, videotape, laser-disc, CD-ROM, and video game cartridges. DVD has widespread support from all major electronics companies, all major computer hardware companies, and about half of the major movie and music studios. The main difference between DVD-ROM and CD-ROM multimedia discs is capacity. DVD-ROM drives also have a minimum 8X playback speed.

A DVD disc has the same appearance as a conventional Audio CD or CD-ROM. and are available in four variations shown in the table below:

Format	Capacity	Sides/Layer
DVD-5	4.7 Gbytes	(1 side, 1 layer)
DVD-9	8.5 Gbytes	(1 side, 2 layers)
DVD-10	9.4 Gbytes	(2 sides, 1 layer)
DVD-18	17.0 Gbytes	(2 sides, 2 layers)

*Double-sided, dual-layer discs (DVD-18s) are not yet commercially available wide range of applications.

even though some of DVD-Recordable drives are designed to read them.

Type of DVD discs

According to Kilroy Hughes (1997), there are six types of DVD discs:

Data Discs

DVD-ROM data discs contain regular data files that can be accessed through International Standards Organization (ISO) 9660 or Universal Disk Format (UDF) file systems, such as those used for archiving. There are no challenging multimedia or real-time performance requirements for playback. Application programs on any computer platforms that support the data format, file system can retrieve data, and DVD-ROM drives.

Multimedia Discs

Multimedia DVD-ROMs are similar to conventional CD-ROM's (i.e. games, encyclopedias, etc.). These usually include a platform-specific application that plays audio through specialized audio hardware, and video using software codecs, with or without hardware acceleration. Media playback architectures like AVI, QuickTime, ActiveMovie, and DirectShow provide the application programming interfaces, file structures, and system controls to play multimedia.

Multimedia with MPEG 1

DVD-ROM discs with MPEG 1 video are intended for TV-quality PC playback. They use the MPEG 1 audio and video format. Most new PCs have the ability to decode MPEG 1, and encoders are inexpensive, making MPEG 1 video production practical for a

The standard resolution of MPEG 1 is one-quarter that of MPEG 2. The video

quality can be better than VHS tape, depending on the bit rate, noise level of the source video, and encoder quality. Any authoring tools can be used as long as they handle the appropriate API commands, such as the OM-1 MPEG MCI (Media Control Interface) command set for Windows. MPEG 1 titles can be published on CD-ROM or DVD-ROM, depending on size. One CD-ROM holds up to 70 minutes of MPEG 1 video play time. It is call Video-CD or VCD.

Multimedia with MPEG 2
The true advantage of the high volume of a DVD disc's capacity is better demonstrated with Multimedia DVD with MPEG 2 video (about 10 minutes). MPEG 2 video offers studio quality video with four times the resolution of MPEG 1 video. MPEG 2 is superior to the S-VHS video in quality. An MPEG 2 title can be stored on a CD-ROM disc. This is a practical and inexpensive way of testing multimedia courseware on DVDs.

DVD-Video
Most DVD-ROM drives will read DVD-Video discs. The production of a DVD Video title is more complicated than a multimedia DVD title because the development platform is different from the playback system, which is a DVD Video player. The authoring systems for DVD Video titles range from $10,000 to $55,000. Use of the specifications or the DVD name in a product may also require a $40,000 license.

Bridge DVD-V
Bridge DVD-Video discs are also called Enhanced DVD, Hybrid DVD, and Multi-Play DVD. This means that the DVD disc is able to play on a DVD-Video player and can be accessed on a PC DVD-ROM drive.

Who are Using DVD?

DVD players and DVD-ROM drives are readily available on the consumer market. The electronics industry is estimating 20-to-50 million per year sales by the year 2000. Toshiba predict a market penetration of 100 million DVD-ROM drives by the turn of the century. To update current computers, the drives will cost about $250 to $800 including the cost of a computer card or board for MPEG-2 decoding.

Like CD-ROM technologies, it did not take very long for DVD to be adopted by the training community. Some government agencies such the FAA National CBI Program also have been studying the feasibility of using DVD in its distance learning programs. The Navy School of Health Science is already offering interactive multimedia courseware on DVDs.

DVD is still a relatively new technology and has not been implemented widely either among the government agencies or private corporations for training. For example, Aviation Industry CBI Committee (AICC) recently addressed DVD issues. The committee notes that new multimedia applications and the advent of DVD drives will bring more MPEG video into courseware. A video card with hardware MPEG playback may become more common and necessary to the training function, but the standard platforms for delivering interactive multimedia courseware still

exclude any DVD specifications. At the same time, AICC standard CBI platform configuration already exceeds the recommended system configuration for consumer level DVD-ROM drives.

Developing Interactive Courseware on DVD

The development team of the courseware is mostly concerned with the first four types of DVD discs. There is very little difference between the multimedia development of courseware on a DVD vs. courseware on a CD-ROM; the only difference being the amount of data such as audio/video files that can be stored on the disc. It is important to note that no file should exceed the maximum size of one gigabyte.

There are basically two stages of DVD production Authoring and mastering-replication.

DVD-ROMs can be developed with traditional software development tools such as Macromedia Director, Authorware, Asymetrix Toolbook, HyperCard, Quark mTropolis, and Visual Basic, C++. Discs, including DVD-R check discs, can be created with UDF formatting software.

DVD-ROMs that take advantage of DVD-Video's MPEG-2 video and multichannel Dolby Digital or MPEG-2 audio require video and audio encoding. At the time of this paper being drafted, the cost of MPEG 2 encoding is still prohibitive in terms of hardware and software investment. Most multimedia DVD authors out source the MPEG 2 compression/encoding.

Most of the conventional training and multimedia authoring systems do not support MPEG2 Video. MPEG2 video can be supported by creating custom drivers, plug-ins, DLLs, or "Xtras" for Macromedia Director and Authorware or Asymetrix Toolbook. If the integration of the movie play with the courseware is not crucial and the system is configured correctly and tested, MPEG 2 movies can be played using the MCI command set for Windows.

The second phase of DVD production is replication. Replication is essentially the same for both CD-ROM production and production of DVD titles of all types.

Cost for DVD Development

According to Taylor (1999), there are basically three stages of DVD costs: production, pre-mastering (authoring, encoding, and formatting), and mastering/replication.

For data discs, multimedia discs, and multimedia discs with MPEG 1 video, the costs beyond the cost for developing and authoring the courseware content illustrated in the following table:

Media	Mastering	Replicate
Videotapes	N/A	$2.40
CD	$1,000	$0.50
Laserdiscs	$3,000	$8.00
DVD	$2,000	$1.70

DVD Mastering and Replication Cost Comparison (As of July 1998).

If the DVD contains MPEG 2 video, typical charges for compression are $120/min for video, $20/min for audio, $6/min for subtitles, plus formatting and testing at about $30/min. A ballpark estimate for producing a two-hour DVD

movie is about $20,000. A simple DVD-Video title with menus and various video clips can cost as low as $3,000. If you want to do it yourself, authoring and encoding systems can be purchased at prices from $400 to over $2 million. These will drop very rapidly in the next few years to where DVDs can be produced on a desktop computer system that costs less than $20,000.

For most training programs, multimedia courseware with MPEG 1 video is sufficient. A DVD disc can hold more than 15 hours of MPEG1 video.

Advantages of DVD

Interactive multimedia on DVD shares most of the advantages of a CD-ROM plus a minimum of seven to twenty-eight times higher storage and faster data rate:

- The most significant advantage of multimedia on DVD-ROMs is the high storage capacity.
- Realistic simulation capabilities.
- Improved learner performance through interaction, reinforcement, and simulation.
- Individualized instruction through branching.
- Reduced training time because learner receives only needed training.
- On-demand availability minimizing training down time.
- Consistent instruction; learner gets the needed training and the organization gets the needed results.
- Reduced instructor dependence, although instructor involvement can enhance effectiveness.
- Effective enhancement of live instruction.

- Delivery of training to remote locations; anywhere the equipment is present, training can occur.
- Capability for presenting a dynamic training environment.

Considerations of DVD

- Like interactive courseware on CD-ROMs, DVD shares some of the disadvantages mentioned earlier within this paper. Information on the DVD is static and ready only. It is difficult and expensive to make changes. The high capacity works as a "double-edged sword." It contains a significant amount of data but also provides many more opportunities for expensive mistakes. A stringent systematic quality assurance procedure must be established and strictly enforced.
- Higher development costs over traditional training methods; these may be offset through reduced ongoing costs.
- The up-front analysis and design work is often performed more rigorously than for stand-up training, so those costs can be higher.
- Learners accustomed to television, video games, interactive kiosks, and videodisc programs may expect more glitz. However, results are the most critical element to user acceptance. If the trainees feel that they have learned, the desire for glitz diminishes.
- Hardware and software incompatibilities can lead to proliferation of systems and programs that are not fully utilized.
- Differences between high performance machines and the machines available for program

delivery can lead to high expectations and frustration.

- Complex programs can create demands for skilled staff to maintain them, or continued reliance on contractor support.

- If you plan to maintain a program in-house, account for this in the design by minimizing the amount of changeable material in the CBT course and conveying it with media that are less expensive to change (i.e., with text and graphics).

- The real key to success is the design, not the hardware or software and this is often overlooked.

- Disc mastering process is slow and expensive compared to CD-ROM.

- Since both MPEG 1 and MPEG 2 can co-exist on the same DVD disc. The hardware and software must be correctly configured to playback the two different types of video files.

- As a relatively new technology, the testing of target systems is extremely important. The more standardized training delivery platform, the better chances are of successfully implementing the new technology.

COMPUTER SUPPORTED COLLABORATIVE LEARNING

As has already been discussed within this paper, communication between the instructor and the student and the student with other students is an invaluable and integral component of the student's learning. No matter how much static information a DVD holds, the student's learning experience will be limited without this interaction. With computer based training (CBT) becoming a more prevalent and cost-effective means of training, online collaboration tools such as instant messaging services (i.e. AOL instant messenger, ICQ, etc.), online conferences (i.e. netmeeting), bulletin boards, chat rooms, web based auditoriums, listservs, and e-mail are becoming important communication tools that allow students to communicate with their instructors and with other students as they would in a traditional classroom setting.

Synchronous Communication
Each of the products listed above works to keep the channels of communication open in different ways. Instant messaging services, online conferences, chat rooms, and web-based auditoriums are forms of synchronous communication. Synchronous communication allows the instructor and student to communicate in real time and receive immediate feedback. Synchronous communication also allows everyone to be aware of whom is online. As the student signs on, he/she receives a list of everyone else who is online. This way, the student can immediately contact classmates and instructors without having to waste time searching. As the student completes the CBT, he/she has the ability to ask questions or comment on what has been learned with other students and the instructors. It becomes a virtual classroom, as instructors and students engage in discussion over the material learned. Many products such as ICQ, AOL instant messenger, etc… allow the instructor to maintain office hours. The instructor can provide a guaranteed time when he/she will be online available to answer students' questions.

Instant messenger services are Internet tools that allow the student to contact others online at will. They keep track of who is online and who is not,

thus making the student's need to search for individuals minimal. As a tool of computer based training, an instant messenger service allows the students to discuss the topic with one another, as well as with the instructor. They also allow the students to share experiences, interact with instructors, and interact with other students. This form of synchronous communication allows both the student and the instructor to obtain immediate feedback on the topics being discussed.

The web-based auditorium is another online collaboration tool that allows communication in real time between an instructor and a student. With a web-based auditorium, on-line classes can be conducted without the physical limitations of a classroom. CBT that utilizes this resource allows the student to listen and respond to a lecture given by an instructor. This is because a web-based auditorium is the implementation of a real world auditorium. Within this program, there is a lobby where the audience attendee can hang around and talk freely until the auditorium doors open. There is the auditorium itself where the audience is seated in rows. There are the screeners, which are optional individuals whom can be deployed, in case of large events, to receive questions from the audience for pre-screening before submitting them to the moderator. There is the speaker, who is the individual(s) on stage making the presentation to the audience. Finally, there is the administrator, who is the individual with full control over setting up and controlling every aspect of the auditorium. A student is able to go to a lecture, ask questions, respond to questions, and interact with everyone there.

Online conferences, a third online collaboration tool, allows users to meet together to conduct meetings online. Many of the online conferencing software products offer features such as a chat window and a shared whiteboard. Participants can invite new people into the conference simply be placing a call, or users can ask to join a conference in progress. A student engaged in CBT can utilize online conferences by scheduling meetings with other students to discuss material learned in the CBT. With such options as a shared whiteboard, the students are able to work out various ideas and problems together.

Asynchronous Communication
Other online communication tools such as e-mail, listservs, and bulletin boards are asynchronous communication tools. The feedback is not immediate, and the communication can be done on the student and teacher's own time. The student can think about a question or comment before posting it on a bulletin board or emailing his/her instructor or classmate. This way, the feedback can be thought out and more extensive than when communicating through forms of synchronous communication.

Benefits to Utilizing Online Collaboration Tools
By utilizing methods such as the ones mentioned above, instructors and students are able to overcome many of the conversational limitations that can exist within more traditional forms of communication. Instructors and students are able to overcome place dependence. By having to communicate solely in a classroom setting, students and teachers are forced to be in one place to get anything accomplished. A second limitation is time dependence.

Without having to worry about conducting class in a certain time-allotment, students are able to work at their own pace. Research has found that the average student's answer in classroom discussion is 12 words long. Those who communicated via email tended, on average, to write 106 words. A third conversational limitation is richness of communication. Because face-to-face communication relies on both verbal and nonverbal behaviors, it can be difficult to find the real message. With email being text-based, the message is unattached from the emotional behavior that is often accompanied by verbal communication. As such, individuals often become more reflective than those communicating verbally, are more attentive from whom they have received messages, and are put on equal footing with all other students. A fifth and final conversational limitation is structure of communication. Inside a classroom setting, instructors are more likely to dominate much of the time allotted for instruction, thereby impeding interaction between students. Online collaboration tools allow students to spend more time interacting with one another, without the instructor managing the majority of the instruction period. Thus, research indicates that online collaboration tools allow students and instructors alike the power to interact with one another at each individual's own personal level.

CONCLUSIONS

The development of a holistic technology based training program will integrate three important components necessary to maximize learning. The first aspect is a hybrid DVD that a high capacity storage device designed in such a way that information is interlinked to the World Wide Web. A second aspect to the HTBT is the use of cutting edge communication technologies. Students and instructors are linked to one another, thereby creating a rich collaborative learning environment. This environment affords the learning experience that a student could before only get in the traditional classroom setting. The third and final aspect to creating a holistic technology based training program is the EPSS that are made available to the student upon completion of his/her training. Integration of these three aspects is an attempt to take technology-based training to a higher level. Thus, it will take the training development community extraordinary efforts to bring HTBT to its fullest potential.

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